Enhanced Fluctuation in Pion Multiplicity as a Signal of Disoriented Chiral Condensates *

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A major goal of relativistic heavy-ion collision experiments is to explore the phase diagram of hot and dense matter. In addition to the anticipated transition to the quark-gluon plasma phase, in which the individual hadrons have dissolved into a chromodynamic plasma of quarks and gluons, it is expected that chiral symmetry will be approximately restored in the hot collision zone. Signals of this latter type of phase transition may arise from the subsequent non-equilibrium relaxation of the chiral order parameter which is expected to exhibit amplification of long-wavelength modes in certain isospin orientation, often referred to as Disoriented Chiral Condensates. It is important to identify specific observables that may be particularly indicative of the underlying chiral dynamics. In this paper we address the pion multiplicity distribution.

We concentrate on in this paper is the difference between the factorial moments of soft and hard pions. It is defined as

$$F_m = \langle N(N-1)(N-2)\cdots(N-m+1)\rangle / \langle N\rangle^m \quad (1)$$

Since the relaxation of the chiral order parameter amplifies mostly soft pion modes, the fluctuations in these soft pions and consequently their factorial moments must exhibit different behavior than pions with large momentum. In this case, it found that normalized factorial moments for soft pions are enhanced as compared to hard pions.

We found that whereas all calculations with HIJING and UrQMD yield a rather similar behavior, namely a gentle increase of factorial moments with order, the linear σ model leads to normalized moments that remain close to unity for the hard pions while increasing rapidly for the soft pions.

This qualitative difference in the behavior can be made more visible by considering the ratios between the normalized moments for soft and hard pions, as shown in Fig. 1. While all the HIJING and UrQMD calculations predict equal multiplicity fluctuations for pions with low and high transverse momenta, the dynamical simulations with the linear σ model yield a strong enhancement of the fluctuations in the number of low-p_T pions. In particular, although both HIJING (with or without jet quenching) and UrQMD produce some enhancement of the multiplicity fluctuations (above a pure Poisson behavior), neither one shows any distinction between soft and hard pions in this regard. Thus it appears that a comparison of the factorial moments of the soft and hard pion multiplicitity distributions may provide a useful observable which could indicacte the presence of interesting dynamics beyond what has been included in the standard event generators.

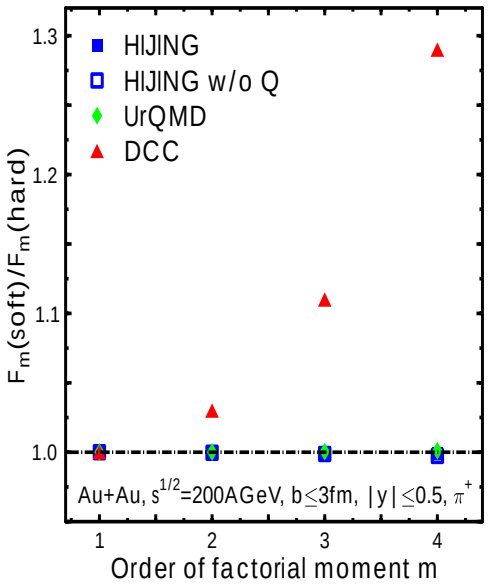

Figure 1: The ratios between corresponding values of the calculated normalized factorial moments F_m for soft and hard pions.

Footnotes and References

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